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(54) **TEST CHIP WITH PLUG FOR MEASURING THE CONCENTRATION OF AN ANALYTE IN A LIQUID, HOUSING FOR TEST CHIP AND SOCKET FOR PLUG**

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USPC 204/450, 549, 600; 422/500, 502, 554, 422/560, 565–566
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,506,554	A	4/1970	Broome
4,242,194	A	12/1980	Steiner et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CA	2737892	9/2003
DE	20 2005 009 960	9/2005

(Continued)

OTHER PUBLICATIONS

Japanese Official Action issued in Application No. 2009/537484 on May 12, 2011.

(Continued)

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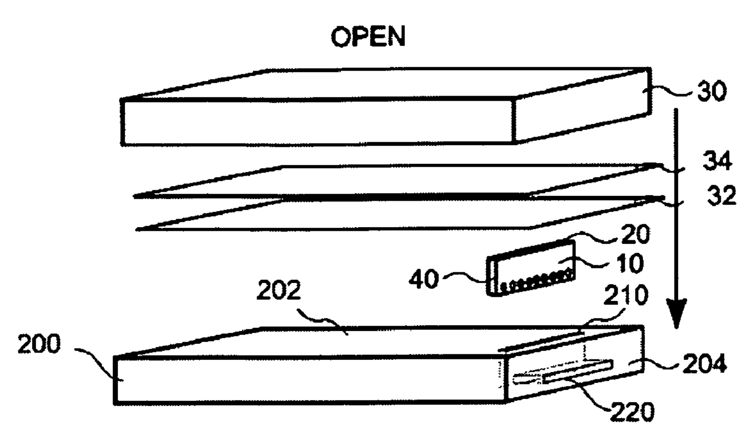
(57) **ABSTRACT**

Measurement device (**10**) for taking a liquid sample, comprising: a measurement portion (**15**) with a measurement surface (**20**), for being in use contacted with the liquid surface and a plug portion (**40**) having a plurality of electrical contacts (**50**), wherein the plug portion (**40**) is mountable to a socket (**110**) of a measurement evaluation apparatus (**100**).

27 Claims, 8 Drawing Sheets



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B23P 17/04 (2006.01)

(52) **U.S. Cl.**
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(56) **References Cited**

U.S. PATENT DOCUMENTS

4,415,418	A	11/1983	Turre et al.	
4,956,062	A	9/1990	Ooi et al.	
5,223,114	A	6/1993	Zare et al.	
5,849,208	A *	12/1998	Hayes et al.	216/94
5,882,496	A	3/1999	Northrup et al.	
5,900,130	A	5/1999	Benvegnu et al.	
5,955,028	A *	9/1999	Chow	422/63
5,989,402	A	11/1999	Chow et al.	
6,090,545	A	7/2000	Wohlstadter et al.	
6,258,254	B1	7/2001	Miyamoto et al.	
6,399,025	B1	6/2002	Chow	
6,432,720	B2	8/2002	Chow	
6,444,474	B1 *	9/2002	Thomas et al.	436/146
6,503,757	B1	1/2003	Chow	
6,730,199	B1 *	5/2004	Hänni et al.	204/403.02
6,864,480	B2	3/2005	Staats	
7,217,352	B2	5/2007	Seino et al.	
7,494,622	B2 *	2/2009	Picollet-Dahan et al.	422/82.01
8,202,492	B2 *	6/2012	Linder	B01L 3/5027 422/50
2002/0025576	A1	2/2002	Northrup et al.	
2002/0027075	A1	3/2002	Manz et al.	
2003/0068646	A1 *	4/2003	Singh et al.	435/7.1
2003/0114785	A1	6/2003	Kikuchi et al.	
2003/0209314	A1	11/2003	Guo et al.	
2004/0037739	A1 *	2/2004	McNeely et al.	422/58
2004/0086872	A1 *	5/2004	Childers et al.	435/6
2004/0089546	A1 *	5/2004	Bahatt et al.	204/450
2004/0126279	A1 *	7/2004	Renzi	B01L 3/502715 422/502
2005/0135968	A1	6/2005	Augstein	
2005/0150766	A1	7/2005	Manz et al.	
2005/0268701	A1	12/2005	Hintsche	
2005/0279635	A1 *	12/2005	Chow et al.	204/601
2006/0204143	A1	9/2006	Shiota et al.	
2007/0051628	A1	3/2007	Dolnik	
2007/0053796	A1 *	3/2007	Gau et al.	422/100
2007/0065346	A1 *	3/2007	Henry et al.	422/100
2009/0302190	A1 *	12/2009	Trieu et al.	248/683
2010/0062082	A1 *	3/2010	Staal et al.	424/722

FOREIGN PATENT DOCUMENTS

EP	215419	3/1987
EP	0295942	12/1988
EP	0631133	12/1994
EP	1016864	7/2000
EP	1413879	4/2004
EP	1486778	12/2004
EP	952890	6/2005
EP	1543935	6/2005
EP	1553395	7/2005
FR	2844052	3/2004
JP	62069139	3/1987
JP	1158342	6/1989
JP	H04501768	3/1992
JP	H053998	1/1993
JP	H0552799	3/1993
JP	10311827	11/1998
JP	2000002677	1/2000
JP	2000227414	8/2000
JP	2000515630	11/2000
JP	2001258868	9/2001
JP	2002527250	8/2002
JP	2002544494	12/2002
JP	2003530566	10/2003
JP	2004020367	1/2004
JP	2004109082	4/2004
JP	2005331411	2/2005
JP	2005134190	5/2005
JP	2006047321	2/2006
JP	2007-006858	1/2007
JP	2007-064742	3/2007
KR	20000066685	11/2000
WO	96/33405	10/1996
WO	98/05424	2/1998
WO	00/67907	11/2000
WO	01/77641	10/2001
WO	03/012421	2/2003
WO	2005/003724	2/2005
WO	2005/094286	10/2005

OTHER PUBLICATIONS

Tjerkstra et al, "Multi-Walled Microchannels: Free-Standing Porous Silicon Membranes for Use in μTAS", Journal of Microelectromechanical Systems, Dec. 2000, pp. 495-501, vol. 9, No. 4.
Invitation to Pay Additional Fees, European Patent Office Form PCT/ISA/2006, Nov. 27, 2007.
Partial International Search Report, European Patent Office Form PCT/ISA/2006 (Annex), Nov. 27, 2007.
Vrouwe, et al, "Direct Measurement of Lithium in Whole Blood Using Microchip Capillary Electrophoresis with Integrated Conductivity Detection", Electrophesis, vol. 25, 2004, pp. 1660-1667.
Vrouwe et al, "Microchip Analysis of Lithium in Blood Using Moving Boundary Electrphesis and Zone Electrophoresis", Electrophoresis, 2005, vol. 26, pp. 3032-3042.
ReliaLAB, Insta Read Lithium System Information Sheet, Jun. 2005, 7 pages.
Eurasian Search Report issued in Eurasian Application No. 200901553/26 on Oct. 13, 2010.
Extended European Search Report issued in European Patent Application No. 12175953.4 on Jan. 14, 2013.
Extended European Search Report issued in European Application No. 12183414.7 on Jan. 30, 2013.
Extended European Search Report issued in European Application No. 12183414.7 on Feb. 6, 2013.
Official Action issued in EP Application No. 12183415.4 on Oct. 22, 2013.
Official Action issued in JP Application No. 2013-069912 on Apr. 8, 2014.
Official Action issued in JP Application No. 2013-069913 on Apr. 8, 2014.

* cited by examiner

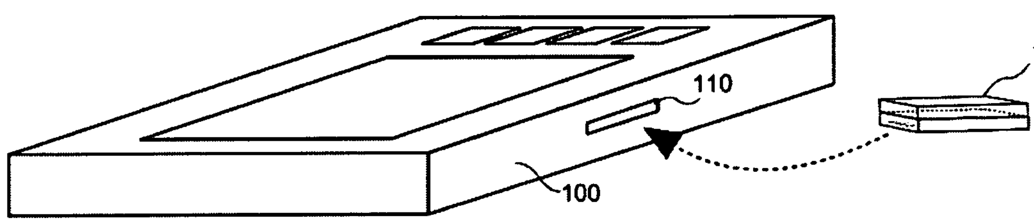


Fig. 1

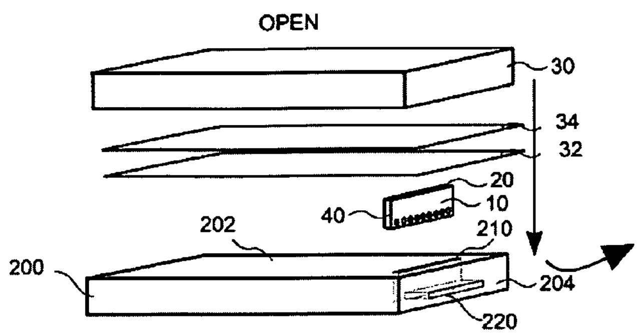


FIG. 2a

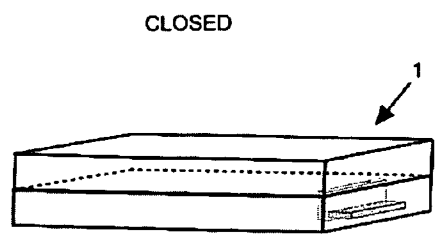


Fig. 2b

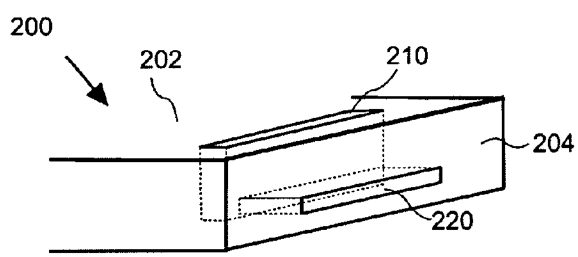


FIG. 2c

FIG. 3a

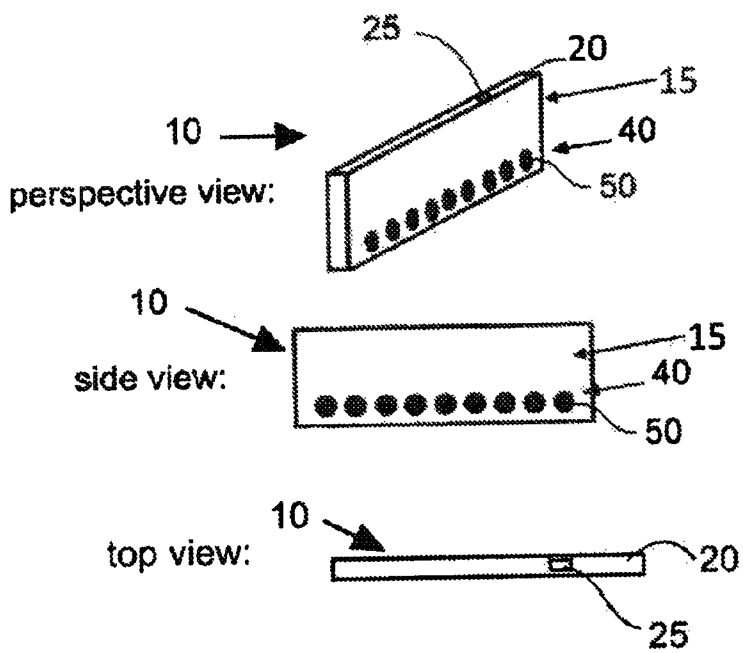
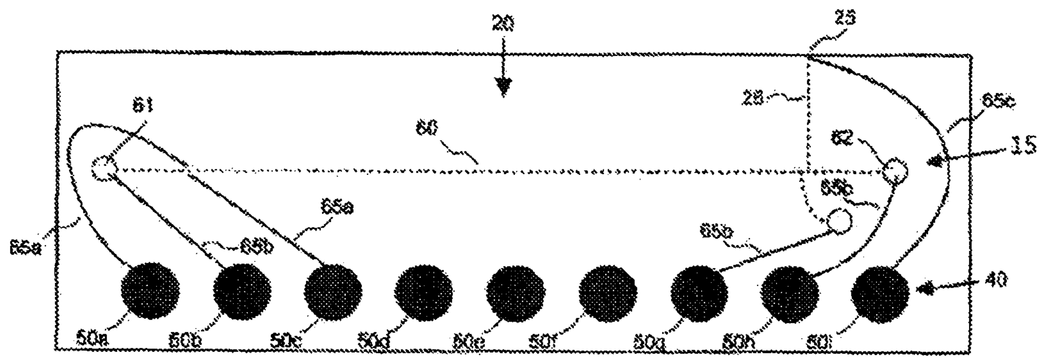


FIG. 3b

FIG. 3c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65a
65b
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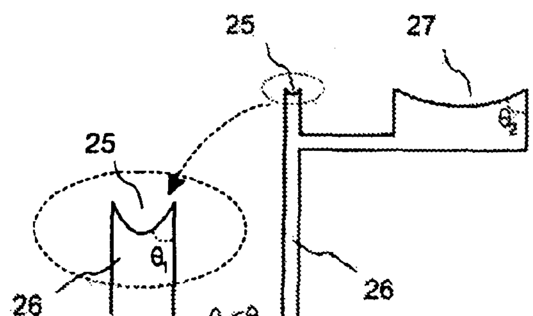
50h
50i

Fig. 4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27
25
θ_2
θ_1
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$\theta_1 < \theta_2$

Fig. 5

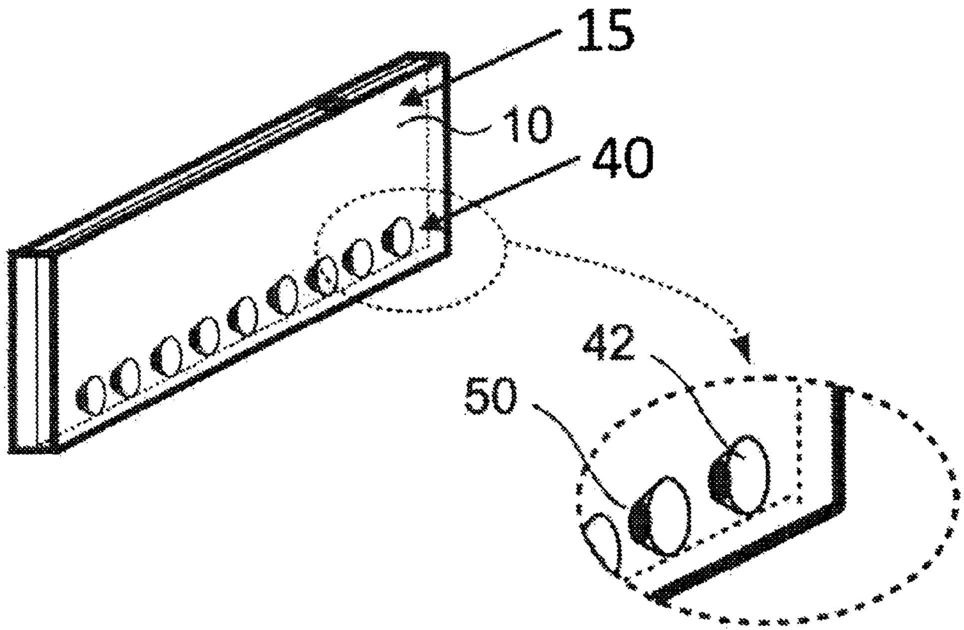

Fig. 6

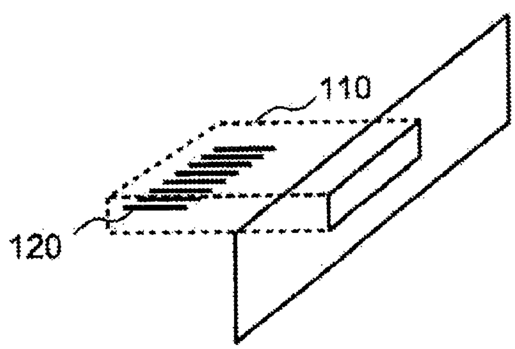

Fig. 7

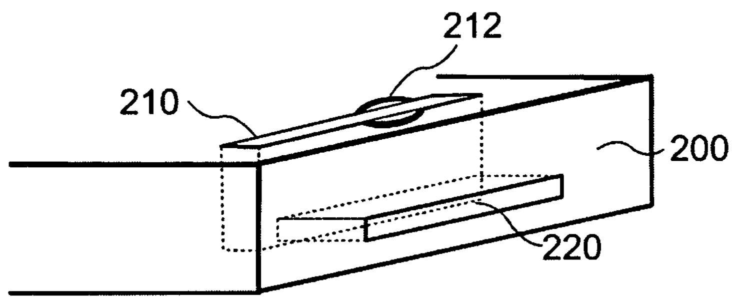

Fig. 8a

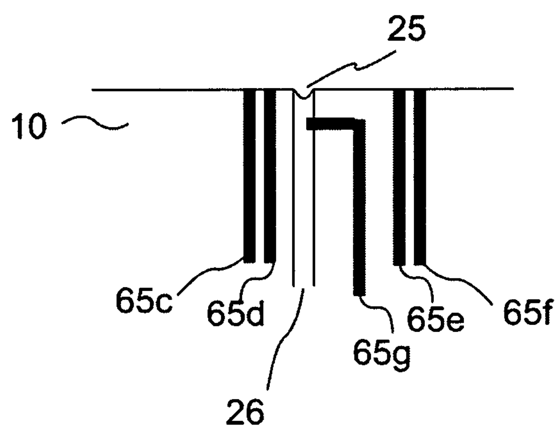

Fig. 8b

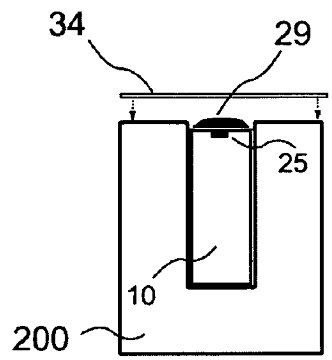

Fig. 9

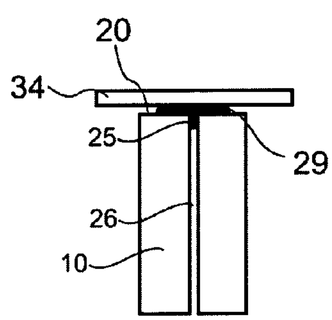

Fig. 10a

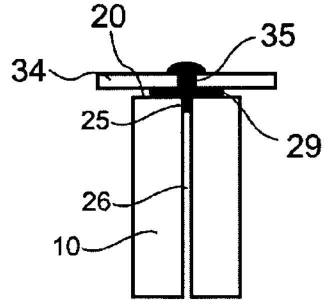

Fig. 10b

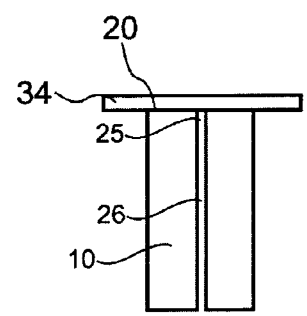

Fig. 10c

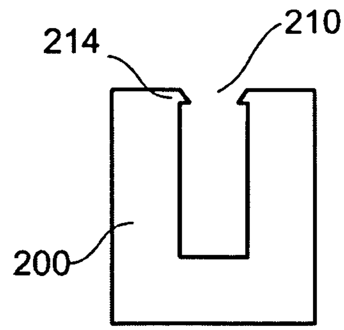

Fig. 11

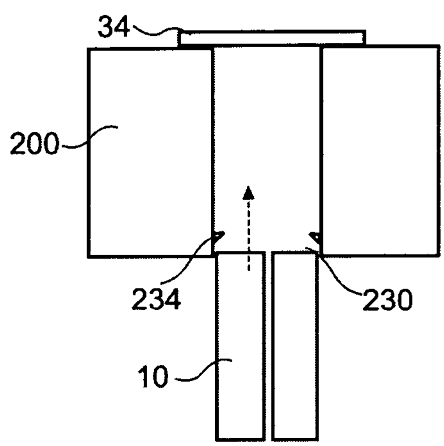

Fig. 12a

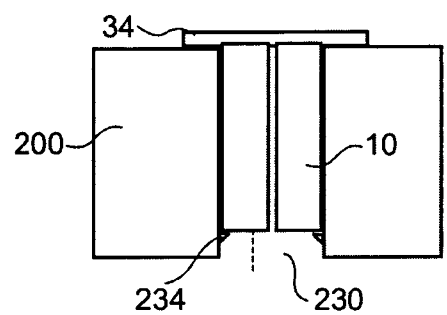

Fig. 12b

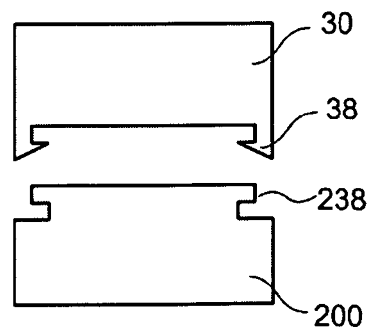

Fig. 13

TEST CHIP WITH PLUG FOR MEASURING THE CONCENTRATION OF AN ANALYTE IN A LIQUID, HOUSING FOR TEST CHIP AND SOCKET FOR PLUG

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a 371 application of International Patent Application No. PCT/EP2007/004468 filed on May 18, 2007 and is related to U.S. patent application Ser. No. 12/515,635 filed on May 20, 2009 which is based on International Patent Application No. PCT/EP2006/11148 filed on Nov. 21, 2006.

FIELD OF THE INVENTION

The invention relates to sensors for components in liquid samples. In particular, the invention relates to sensors for evaluating charged species concentrations, in particular ion concentrations, for example lithium ion concentrations, in samples, such as blood that can be easily handled by a user, i.e. a patient.

BACKGROUND AND RELATED ART

Inorganic ions are an essential requirement for life and are found in large amounts in drinking water, blood and cells of an organism as well as in the environment. For example, the presence of many ions, e.g. sodium, potassium, magnesium, and calcium, inside and outside of the cells is essential for a living organism. Consequently, a measurement of the ion concentration in the blood and in blood cells of animals and human beings is of high importance for a large variety of body functions.

Normally lithium is not at all or solely as a trace element present in the blood plasma, but it is also used as a drug to treat bipolar mood disorder. It is estimated that worldwide over one million people take lithium on a daily basis. A disadvantage in the use of lithium is the very low therapeutic index, i.e., the ratio between the toxic concentration and the therapeutic concentration. Most patients respond well to a blood plasma concentration of 0.4-1.2 mmol/L lithium while a lithium concentration of above 1.6 mmol/L is considered toxic. A prolonged high blood lithium level can result in permanent damage to the nervous system and even death. Monitoring of the lithium concentration during treatment is therefore essential, with regular checks every couple of months to keep the lithium level at desired level.

The direct measurement of lithium in whole blood and the determination of inorganic cations in blood plasma have been described and demonstrated by E. Vrouwe et al. in *Electrophoresis* 2004, 25, 1660-1667 and in *Electrophoresis* 2005, 26, 3032-3042. Using microchip capillary electrophoresis (CE) with defined sample loading and applying the principles of column coupling, the concentration of alkali metals in the blood was determined in a drop of whole blood. Blood collected from a finger stick was transferred onto a chip without extraction or removal of components from the blood. The lithium concentration can be determined in the blood plasma from a patient on lithium therapy without sample pre-treatment. Using a chip with conductivity detection, a detection limit of 0.1 mmol/L has been obtained for lithium in a 140 mmol/L sodium matrix.

In these disclosures, the components of the blood sample are separated electrophoretically inside a micro-channel. A double T injection geometry is used to select the ion components of interest and to guide them to detection electrodes.

A method and an apparatus for measuring the ion concentration in liquid samples is disclosed in the co-pending PCT application PCT/EP2006/011148 the teachings of which are included by reference herewith. This PCT application describes an apparatus for the measurement of a concentration of a charged species in a sample, the sample comprising a plurality of types of charged species and at least one insoluble component, the apparatus comprising at least one channel with at least one opening with a filter function, at least two electrophoresis electrodes arranged along the at least one channel, and at least one sensor for measuring at least one type of charged species in the at least one channel.

The dimensions of the opening and the channels used in such an apparatus are usually very small in order to reduce the amount of liquid necessary and the size of the apparatus. Typical channel dimension are in the order of less than 1 cm in width and less than 100 μm in depth. Consequently the apparatus can be quite small as well in order to minimize the amount of material used for the apparatus. The material is often expensive as for example glass.

The apparatus should also be easily usable by a patient or other user. In particular, the patients suffering from bipolar mood disorder or similar illnesses, often suffer from quivering or shaking hands and encounter problems in handling small pieces.

Furthermore blood sample and consequently the channels can be easily contaminated by blood or other liquids and can not be reused without intensive cleaning and sterilisation.

In contrast, the known prior measurement devices are complex microfluidic and electronic components that are expensive and therefore not suited for one-time use only.

It is an object of the present invention to provide a device and a method for easy handling of liquid sample measurement devices for measuring small samples.

It is a further object of the invention to provide measurement devices that can be used as disposables while advanced measurement techniques can be employed.

SUMMARY OF THE INVENTION

These and other objects of the invention are met by a measurement sample handling device and a method for taking a liquid sample according to the invention, wherein the measurement sample handing device comprises a measurement device and a handling unit.

The measurement device for taking the liquid samples comprises: a measurement portion with a measurement surface for being in use contacted with the liquid sample and a plug portion having a plurality of electrical contacts, wherein the plug portion is mountable to a socket of a measurement evaluation apparatus. The measurement surface may be arranged at a different position of the measurement device than the plug portion in order to avoid liquid of the liquid sample to come into contact with the electrical contacts. In particular, the plug portion may be arranged at a different side of the measurement device, than the measurement surface.

The measurement surface and the measurement portion may be made form the same material, for example from glass and may be realized in one piece. The measurement device may further comprise a plurality of electrodes coupled to the electrical contacts. The measurement device may neither have any active electrical components, such as switches, transistors nor an electrical power supply. In some cases the measurement device may comprise some passive electrical components such as temperature sensors or the like.

During assembly, the measurement device might be inserted into a handling unit the handling unit having a first opening for the measurement surface and at least a second opening for the plurality of electrical contacts. Thus when inserted into the handling unit, the measurement surface is accessible by a user or patient for placing a liquid sample. On the other side the plug portion is accessible through the second opening of the handling unit for allowing access to the electrical contact, for example by a socket. Thus, the handling unit may form an electrical contact seal for preventing liquid to come into contact with the electrical contacts at the plug portion of the measurement device.

The handling unit may not comprise any electrical components as all electrical contacts are provided by the measurement device. In some cases, however, the handling unit may comprise electrical contacts and electrical components.

The handling unit may be substantially large in size than the measurement device. Thus the handling unit can be of handy size for easy and safe handling of the measurement sample handling device even by patients suffering from shaking hands or similar. In the same time the measurement device can be kept small in order to minimize the amount of liquid sample necessary for reliable measurements. In addition the smaller measurement devices may be cheaper to produce. The measurement sample handling device can thus be a disposable device that is for few time or one-time use. This is in particular useful if the liquid sample is a body fluid such as blood or another sample that requires sterile and/or clean environment.

The handling unit may also be adapted to accommodate a plurality of measurement devices, for carrying out a plurality of sample measurements in a row or in parallel.

The measurement device may also be positioned at a particular side of the handling unit, for example such that the second opening provides in use easy access to the plug portion from the outside, for example by a plurality of electrical pins, when the measurement sample handling device is inserted into a socket of a measurement evaluation device. The plurality of electrical pins may be arranged to come into electrical contact with the plurality of electrical contacts of the measurement device, when the measurement device or the measurement sample handling device is mounted to the socket.

The measurement evaluation device for evaluating at least one parameter of the liquid sample may comprise a power supply for the measurement device and all further electric and electronic means to carry out a measurement for evaluating the at least parameter. In particular, the measurement evaluation device may comprise control means for controlling and monitoring the electrodes in the measurement device, when the measurement device is inserted into the socket.

The invention also comprises a method for evaluating at least one parameter of a liquid sample comprising: placing the liquid sample on a measurement surface of a measuring device, wherein the measuring device has a plurality of electrical contacts, inserting the measuring device into a socket having a plurality of electrical pins such that at least some of the plurality of electrical pins come into contact with at least some of the plurality of electrical contacts, and determining the at least one parameter by electrical measurements.

The measurement device may also be part of a measurement sample handling device and comprise a handling unit.

The method can be advantageously applied by patient or elderly users, even with shaking hands. A liquid sample, such a blood sample or another body fluid is placed on the measurement surface prior to insertion of the measurement device into the socket. Thus, no electrical power is present in the measurement device when handling the liquid sample. Furthermore, a measurement of the liquid sample can only be started once placing of the sample on the measurement surface has been finished. In some cases, the measurement surface may be concealed by a closure device to protect the liquid sample and/or to prevent evaporation.

The invention also comprises a method for the assembly of the measurement sample handling device, the method comprising: filling at least one channel in a measurement device having a measurement surface and a plug portion, with a solution, the at least one channel having at least one channel opening in the measurement surface, inserting the measurement device into an opening of a handling unit, such that the measurement surface of the measurement device is accessible, and closing the channel opening with a protective layer to be removed prior to use of the measurement device.

This allows for easy fast and cheap production of the measurement sample handling device.

The insertion of the measurement device into the handling unit may be performed through the first opening. The measurement device may also be inserted through a third opening, for example on the opposite side of the handling unit. The second opening may also be enlarged or combined with the third opening to enable insertion of the measurement device into the handling unit.

Inserting the measurement device into the opening of the handling unit and closing or sealing the channel opening which may be performed directly after filling the at least one channel in order to prevent evaporation of the liquid.

The measurement environment may also be kept in a wet or humid environment prior to closing or sealing the channel opening may be performed directly after removing the measurement device from the wet or humid environment.

The at least one channel in the measurement device may be filled with a solution prior to use. The solution may be an electrolyte solution (BGE). The solution may also comprise an electroosmotic flow suppressing substance or a dynamic coating such as poly vinyl alcohol (PVA).

The term prior to use is in this respect understood as being prior to use of the measurement sample handling device by a patient or a user. Prior to use may also include prior to shipment to the user or the patient.

DESCRIPTION OF THE DRAWINGS

The invention may be better understood with respect to the figures and the detailed description of preferred embodiments, which is illustrative only and not limiting to the invention and wherein:

FIG. **1** shows a measurement system according to the invention comprising a measurement evaluation device with a socket for a measurement sample handling device comprising a handling unit and a measurement device.

FIGS. **2***a* to **2***c* show the disposable device according to the invention in an exploded view, assembled and a portion of the disposable device in greater detail.

FIGS. **3***a*, **3***b*, and **3***c* show the measurement device in a perspective view, side view and top view, respectively.

FIG. **4** shows a schematic view of the measurement device in greater detail.

FIG. **5** shows a detailed view of a specific embodiment of two openings of the measurement device.

FIG. **6** shows the plurality of electrical contacts of the measurement device according to the invention in more detail

FIG. **7** shows the socket of measurement evaluation device in greater detail.

FIGS. **8***a* and **8***b* shows a finger tip positioning tool on the handling unit and a plurality of opening and control electrodes at the opening.

FIG. **9** shows a cross sectional view of the handling unit with the measurement device inserted and a sealing droplet.

FIGS. **10***a* to **10***c* show variants of the sealing and a sealing droplet attached to the measurement device.

FIG. **11** shows the handling unit with a locking device for fixing the measurement device in the handling unit.

FIGS. **12***a* and **12***b* show the insertion of measurement device into the handling unit through a third opening in the handling unit.

FIG. **13** shows a locking mechanism for closing the handling unit with the closure device.

In the figures same reference numerals describe the same or similar objects.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** shows a measurement system comprising a combination of a measurement evaluation apparatus **100** having a socket **110** and a measurement sample handling device or disposable device **1** comprising a measurement device **10** (shown in FIG. **2***a*) attachable to the socket **110**. The measurement evaluation apparatus **100** comprises electronics for computing and evaluating a species ion concentration taken from a sample in the measurement sample handling device **1**. The measurement evaluation apparatus **100** may comprise controls for controlling and checking the measurement and evaluation process. The measurement evaluation apparatus **100** may also comprise indication means, such as a display or similar, to indicate results and setting of the measurement system to a user. The indication means is not shown in the figure. The measurement evaluation apparatus **100** may also comprise interfaces for connecting the measurement system to a computer or a clinical data system (not shown) for data transfer and measurement system control. The measurement evaluation device **110** may also be a personal computer equipped with a socket **110** for receiving the measurement sample handling device **1**.

The measurement sample handling device may be a one-time use disposable that is only used for one measurement. The disposable device may, however, also be used for several times, for example for repetitive or parallel measurements. The terms disposable device and measurement sample handling device are used as synonyms within this disclosure.

FIGS. **2***a* to **2***c* show the measurement sample handling device **1** in more detail. In FIG. **2***a* an exploded view is illustrated, an assembled view is illustrated in FIG. **2***b* and in FIG. **2***c* the portion of the measurement sample handling device **1** that can be attached to the socket **110** is illustrated in greater detail. The measurement sample handling device **1** also comprises a handling unit **200**. The handling unit **200** has a first opening **210** on a first side **202**, defined to be the measurement side, and a second opening **220** at a second side **204** of the handling unit **200** as illustrated in FIGS. **2***a* and **2***c*. The second surface **204** faces towards the socket **110** of the measurement evaluation device **100** when the measurement sample handling device **1** is mounted in the measurement evaluation apparatus **100**. The first opening **210** and the second opening **220** may also be arranged at the bottom face, at the edge of the bottom face and the second face **204** of the handling unit **200** or at any other side of the handling unit **200**. The openings may also be enlarged in size to enable the insertion of the measurement device **20** into the handling unit **200**.

The first opening **210** and the second opening **220** are interconnected inside the handling unit **200** as illustrated by the dotted lines in FIGS. **2***a* and **2***c*.

The measurement device **10** is inserted into the first opening **210** of the handling unit **200**. The measurement device **10** has a measurement surface **20** and a plug portion **40**. The measurement device **10** may also be inserted through second opening **220** or a third opening **230** as will be explained with respect to FIGS. **9** and **12***a,b*. The measurement surface **20** is substantially in the same plane as the first side **202** of the handling unit **200** when the measurement device **10** is inserted in the handling unit **200**. Thereby, the plug potion **40** is accessible from the outside of the measurement sample handling device **1** through the second opening **220** of the handling unit **200**. The measurement device **10** is described in further detail below with respect to FIG. **3**.

The measurement device **10** may be made from a different material that the handling unit **200**. In particular, the measurement device **10** may be made partially or completely from glass material, whilst the handling unit **200** is made from plastics material.

The measurement device **10** may also be formed from polymer material.

The measurement device **10** is much smaller in size than the handling unit **20**. Thus millimeter dimensions of the measurement device **10** may be implemented, while the measurement device **10** can be easily handled with the handling unit **200**. The size of the handling unit **200** can be adapted to the needs of the user (patient). For example, the handling unit **200** may have dimensions that provide an easy handling even with shaking hands. For example, the size of the handling unit **200** may be larger than 1 cm, in particular about 4 cm or more in at least one dimension. In addition, at least the second side **204** of the handling unit **200** is adapted to fit into the socket **110**. The side faces or other geometrical parameters of the handling unit **200** may also be adapted to fit into the socket **110**.

The socket **110** and the handling unit **200** may be formed in a way that there is only one possibility of inserting the disposable or measurement sample handling device **1** comprising the handling unit into the socket **110**. Thereby faulty operation by unexperienced or elderly users or patients can be excluded and measurement errors can be avoided.

The measurement device **10** may be arranged close to the second side **204** when inserted inside the handling unit **200**. Thus, the measurement device is close to the socket **110** when the measurement sample handling device **1** is inserted into the socket **110**. The measurement device **10** may be arranged inside the handling unit **200** such that side of the measurement device **10** comprising the plug portion **40** is parallel to the second side **204** when inserted into handling unit **200**.

The handling unit **200** and the measurement surface **20** might be covered by a permeable layer **32** (as seen clearly in FIG. **2***a*) for providing access to the measurement surface **20** of the measurement device **10**. The permeable layer **32** may completely or partially cover the measurement side **202** and the measurement surface **20**.

A sealing **34** is provided on top of the measurement side **202** for sealing the permeable layer **32** or the measurement surface **20** for preventing leakage or evaporation of fluids. The sealing layer **34** may be removed by the patient or user prior to use of the measurement device. The permeable layer **32** and the sealing **34** may be of different size. A person skilled in the art will understand that more or fewer layers may be arranged on top of the measurement surface **20** or the first surface **202**.

A closure device **30** may be used for closing the measurement surface **20** prior to and/or after use. The sealing **34** and permeable layer **32** may be attached to the measurement device **10**, the closure device **30** or to the handling unit **200**.

The handling device **200** and the closure device **30** may be made from the same material, for example plastics material. The handling device **200** and the closure device **30** may also be made in one piece. An integral hinge may be provided for separating the closure device portion form the handling device portion and for enabling folding of the closure device on top of the handling device in order to conceal or close the measurement surface **20**.

FIGS. **3***a*, **3***b*, and **3***c* show the measurement device **10** in a perspective view, a side view and a top view, respectively.

The measurement device **10** has a first opening **25** in the measurement portion **15**. A microfluidic channel **60** (shown in FIG. **4**) is implemented in the measurement portion **15** inside the measurement device **10**. The first opening **25** provides an access from the surroundings of the measurement surface **20** to the microfluidic channel **60**. A person skilled in the art will understand that a plurality of openings **25** can be provided and that the microfluidic channel **60** can comprise a network of different ones of the channels **60** which are realized in the measurement device **10**. An example for a channel **60** with a first opening **25**, that is particularly useful with the present invention can be found in the patent application PCT/EP2006/011148. The measurement device **10** may be at least partially formed in glass material or another material that can be microstructured.

The first opening **25** may be in the measurement surface **20**. The first opening **25** may also be in another side of the measurement portion **15** of measurement device **10** in close proximity to the measurement surface **20** to which the liquid sample is applied. In this case the liquid sample will go from the measurement surface **20** to the first opening **25**

The plug portion **40** is arranged at a different side of the measurement device **10** than the measurement surface **20** comprising the first opening **25**. Thus, when inserted into the handling unit **200**, the plug portion **40** is only accessible through the second opening **220** of the handling unit **200** while the measurement surface **20** is solely accessible through first opening **210** of the handling unit **200**. The handling unit **200** may thus provide a seal that ensures that the liquid sample that is in use added to the measurement surface **20** can not come into contact with any of the plurality of electrical contacts **50**. Thus, electrical short-circuits between two or more of the plurality of contacts **50** that would impair a measurement or control of functions of the measurement device **10** can be advantageously excluded.

The plug portion **40** and the measurement surface **20** may also be arranged on the same side of the measurement device **10**. However, the plug portion **40** and the measurement surface **20** are separated form each other by a sealing portion of the handling unit **200** when the measurement device **10** is inserted into the handling unit **200**. Thus, liquids on the measurement surface **20** are prevented from coming into contact with electrical contacts of the plug portion **40**.

FIG. **4** shows a schematic view of the measurement device **10** in the view of FIG. **3***b* in greater detail. The microfluidic channel **60** is arranged between two microfluidic reservoirs **61** and **62**. The microfluidic channel **60** further has the first opening **25** in the measurement surface **20**. The first opening **25** may be connected via a sample channel **26** with the microfluidic channel **60**.

In addition, electrodes **65** may be integrated in the measurement device **10**. The electrodes **65** may be constructed as electrophoresis electrodes **65***b* and **65***c* for separating charged species in the sample inside the microfluidic channel **60**. An electrophoresis electrode **65***b* may be integrated in each ones of the reservoirs **61**, **62**, **64**. The reservoirs **61**, **62**, **64** may be closed, such that the microfluidic channel **60** provides the only access to the reservoir **61**, **62** **64** In this way the liquid inside the reservoir is prevented from evaporation and gas formation. The reservoirs **61**, **62**, **64** may be substantially larger in size that the width, height or depth of the microfluidic channel **60**.

Each ones of the electrodes **65***b* are in electrical contact via electrical path with electrical contact **50***b*, **50***h* and **50***g*, respectively. Thus electrophoresis inside the microfluidic channels **60** can be controlled by applying voltages independently to each ones of the electrophoresis electrodes **65***b* by the measurement evaluation device **100** when the measurement device **10** is attached to the socket **110**. The opening electrode **65***c* may be integrated at the first opening **25** and connected with electrical contact **50***i*. The opening electrode **65***c* may also serve as an electrophoresis electrode or as a control electrode as will be explained later.

The electrodes **65** may also be provided as conductivity electrodes **65***a* for measuring the conductivity in a section of the microfluidic channel **60** for determining a charge concentration in this section of the microfluidic channel **60**. The conductivity electrodes **65***a* are connected to and addressed by electrical contacts **50***a* and **50***d* (as illustrated in FIG. **4**) and thus controlled by measurement evaluation device **100** when the measurement device **10** is attached to the socket **110**.

The electrophoresis electrodes **65***b* in capillary electrophoresis system may be based on material that can adsorb hydrogen atoms due to its intrinsic characteristics, for instance palladium or platinum. The adsorption makes it possible to prevent gas formation for example of hydrogen near the electrophoresis electrode **65***b* used as a cathode.

The use of palladium or platinum as material is in particular useful for the electrophoresis electrode **65***b* used as a cathode but the other ones of the electrodes **65** may also be made from the same material.

The electrophoresis electrode **65***b* and/or the opening electrode **65***c* used as anode may also be made from a different material in order to prevent oxygen gas formation. For instance, the electrophoresis electrode **65***b* used as anode may be a silver/silver chloride electrode or may be made from copper. In this case, chloride and solid silver or copper ions will be formed instead of oxygen.

Palladium, platinum, nickel, silver/silver chloride and/or copper as well as further materials may also be mixed in one or more of electrodes **65** to combine the advantages of each material.

One or more of the electrodes **65**, **65***a*, **65***b*, **65***c* may also be provided with an adhesive layer made from en inert metal such as tantalum or chrome.

The measurement device **10** may further comprise electric components, such as temperature sensors, pH sensors and others that may be electrically contacted and controlled with the remaining electrical contacts **50***c*, **50***c* and **50***f*. It is obvious to a person skilled in the art that the number of the plurality of electrical contacts **50**, **50***a* to **50***i* is purely exemplary and that more or less electrical contacts can be provided within the scope of the invention.

It is an advantage of the present invention that the measurement device **10** can comprise solely passive electrical components such as wires, conductors and electrodes. No active component, such as transistors, diodes, flip-flops or similar other active electronic components are necessary. The measurement device **10** may be electronically controlled by the measurement evaluation device **100**. However, sensors may be integrated into measurement device **10** that can comprise semiconductor elements that may also be active semiconductor elements in some cases.

FIG. **5** shows a detailed view of a specific embodiment of the first opening **25** of the measurement device **20** that is connected to the microfluidic channel **60** by the sample channel **26**. In addition, a second opening **27** may be provided, for example to prevent evaporation of fluids. The second opening **27** is fluidly connected to the sample channel **26** and the first opening **25**. The second opening **27** may be substantially larger in size than the first opening **25**. The difference in size results in different contact angles $\square_1$ and $\square_{\square}$ at first opening **25** and second opening **27**, respectively, when a liquid is filled into the microfluidic system and sample channel **26**. The difference in the contact angle $\square_1$ and $\square_{\square}$ will result in a pressure difference in the first opening **25** and the second opening **27** that will, when the liquid is allowed to evaporate from the first opening **25** and the second opening **27**, result in the level of the liquid remaining at essentially the same level in first opening **25** while the liquid level goes down in second opening **27** due to evaporation.

A person skilled in the art will understand that further openings with different of identical sizes can be added on order to modify the evaporation behaviour at the first opening **25**.

FIG. **6** shows the plurality of electrical contacts **50** in more detail. Each of the plurality of electrical contacts **50** may be arranged inside a hole **42** formed in the plug portion **40** of the measurement device **10**. For example an electrical contact may be provided at the bottom of the hole **42**. As illustrated each one of the plurality of electrical contacts **50** will be positioned in a separate hole **42**. In some cases, two or more of the plurality of electrical contacts **50** may also be arranged together in a single one of the holes **42**. In some cases, holes **42** may be provided without any contacts in case the measurement device **10** provides only some functionality. For example, the electrical contacts **50***d*, **50***e* and **50***f* shown in FIG. **4** may be left out if no further electrical component are used. However, the plug portion provides corresponding holes **42** providing space for the corresponding pins of the socket **110**.

The hole **42** may be round and of cylindrical shape or conical shape or have any other shape known to a person skilled in the art. The conical shape may be used to align or guide pins of the socket **110** towards each of the plurality of contacts **50**. Other shapes of the holes **42** may also be implemented within the scope of the invention.

Furthermore, the layout or arrangement of the electrical contacts may be varied and is by no means limited to the line-arrangement illustrated in the Figures.

It is a feature of the present invention that all electrical contacts of the measurement sample handling device **1** are arranged in the measurement device **10** and that the handling unit **200** does not comprise any electrical components, such as contacts, wiring etc.

FIG. **7** shows the socket **110** of measurement evaluation device **100** in greater detail. The socket **110** may be provided in a side wall of the measurement evaluation device **100** as illustrated in FIG. **1** or may be provide in a separate socket container that is electrically connectable to the measurement evaluation device **100**.

The socket **110** comprises a plurality of pins **120** that is arranged in a pattern corresponding to the plurality of contacts **50** of the measurement device **10** such that when the measurement sample handling device **1** is inserted into the socket **110**, at least a portion of the plurality of pins **120** comes into electrical contact with at least one of the plurality of contacts **50**. The number of the plurality of pins **120** may be inferior, equal or superior to the number of contacts **50** of the measurement device **10**. Thus, the same socket **110** and consequently the same measurement evaluation device **100** may be used with a plurality of different measurement devices **10**. The measurement devices **10** may differ in the number of electrical contacts **50**, for example due to additional sensors, like temperature, pH sensors or similar, that are integrated in the measurement device **10**, or due to a different number of electrodes **65** for different applications of the measurement device **10**. Although the number of electrical contacts **50** may vary, the number and shape of the holes **42** in the plug portion **40** might be adapted to the number and shape of pins **120** in the socket **110** in order to provide correct contact and positioning for each of the pins **120** when the measurement sample handling or measurement sample handling device **1** with the measurement device **10** is inserted into the socket **110**.

The plurality of pins **120** may be made of electrical spring contacts in order to ensure the contact of the plurality of pins **120** with the corresponding ones of the plurality of electrical contacts **50** when the measurement device **100** is inserted into the socket **110**. The spring contacts may recede and thus prevent damage on the measurement device **10**, when the measurement device **10** is inserted into the socket **110** and the electrical contacts **50** are forced against the pins **120**.

The plurality of pins **120** may be arranged inside the socket **110** as illustrated in FIG. **6**. Thus, when the measurement sample handling device **1** or solely measurement device **10** is introduced into the socket **110**, the measurement device **10** is completely or partially positioned inside the socket **110**. In this case no modification to the sample on the measurement surface is possible after the measurement is started and no electric contacts are necessary in the handling unit **200** while keeping the measurement device **10** small and therefore cheap

In addition, a direct electrical connection with a patient or other user is impossible. Therefore the measurement device can be safely used by a patient or other user without specific training or care. This is important because high voltages, e.g. in the range or 1000 Volts may be used during measurement of the sample.

The measurement evaluation device **100** may only start a measurement when the measurement sample handling device **1** with the measurement device **10** is inserted correctly into socket **110**. For example, a measurement may only be started if the required ones of the contacts **50***a* to **50***i* are actually in contact with the corresponding pins.

The actual measurement may only be started after successful control measurements are carried out in order to ensure correct operation of the measurement device **10**. A control measurement may be for example measuring the sodium concentration in the liquid sample **5**. The sodium concentration may be measured and evaluated substantially in parallel to the actual measurement of the lithium concentration. For a successful control measurement, the sodium concentration has to be in a range corresponding to that which is usually found in blood. In case a different sodium concentration is evaluated, something went wrong in the measurement and it can not be ensured that the evaluated lithium concentration is correct. The measurement would therefore be ignored.

Additional and initial controls can be performed, for instance measuring the conductivity or the temperature of the background electrolyte solution (BGE), in order to check the correctness of for example sodium concentrations.

FIG. **8***a* shows a specific embodiment of the invention with a finger tip positioning tool integrated in the handling unit **200** described in detail above with respect to FIGS. **2***a* to **2***c*. A rim **212** is provided on one or more sides of the first opening **210** in the measurement side **202** of the handling unit **200**. The rim

212 has the shape and height that it can easily be felt and or seen by a user (patient) using the measurement sample handling device **1** when putting a finger on top of the measurement side **202**. The rim **212** may be arranged along the first opening **210** around the position, at which the opening **25** is located when the measurement device **10** is inserted into the handling unit **200**. The rim **212** may thus serve as a positioning tool for depositing a liquid or blood sample onto the opening **25** at the measurement surface **20**, as it may be felt by the finger tip of a user or because the rim may be simply seen by eye. This is in particular useful because the opening **25** itself may be too small to be seen by the user (patient) by eye.

A cavity or groove in the measurement surface **20** may also be used as positioning tool. The cavity or groove has the further advantage that the cavity or groove serves as collector for sample liquid and that can prevent sample liquid from leaking or spreading onto the measurement device.

The opening electrode **56***c*, present at the first opening **25** as illustrated in FIG. **4** or FIG. **8***b*, may be used to detect the presence of sample liquid on or around the first opening **25**. For example, the opening electrode **65***c* can be present at a certain position or height within the positioning cavity or groove. Thus the presence of a sample liquid **5**, and moreover, the presence of a certain amount of sample liquid can be checked in order to ensure that the required amount of sample liquid has been added, that is necessary for reliable measurements.

FIG. **8***b* shows an example how additional electrodes can be arranged at the first opening **25**. In addition to the opening electrode **65***c*, at least one control electrode **65***d*, **65***e*, and **65***f* can be used. The at least one control electrode **65***d*, **65***e*, **65***f* can be arranged close to the first opening **25**, for measuring additional parameters such as conductivity of the liquid sample. For example, the conductivity of a liquid sample can be measured between the control electrode **65***d* and the control electrode **65***e*. The electrode **65***f* can be from a different material or can have a coating for measuring a different parameter of the liquid sample.

A channel electrode **65***g* may be provided in proximity to the first opening **25**. The channel electrode **65***g* is in contact with the solution inside the sample channel **26**, when the sample channel is filled with an electrolyte solution. In case evaporation of the electrolyte solution should occur, the level of the electrolyte solution would sink below the channel electrode **65***g*, which can be easily detected by conductivity measurements.

The channel electrode **65***g* as well as the opening electrode **65***c* and the control electrodes **65***d*, **65***e*, and **65***f* can thus be used for initial control measurements as for instance as indication for initial conductivity or evaporation and or gas bubble detection.

The opening electrode **65***c* or the control electrode **65***d*, **65***e* or **65***f* or the channel electrode **65***g* may also be used as electrophoresis electrode, for example for capillary electrophoresis inside the sample channel **26**.

FIG. **9** shows a cross sectional view of the handling unit **200** with the measurement device **10** inserted. Prior to use, a sealing droplet **29** may be placed at least on top of the opening **25**. The sealing droplet **29** may be from silicone, PDMS or other material and covers the opening **25** and thus the microfluidic channel **60** in order to prevent evaporation and contamination. The sealing **34**, described above with respect to FIG. **2***a*, may be a sticky foil for covering the measurement surface prior to use. The sealing droplet **29** may stick to the sticking foil. The user (patient) may remove the sticky foil and in the same time the sealing droplet **29** sticking to it, thereby providing access to the opening **25**.

FIGS. **10***a* to **10***c* show different arrangements of the sealing **34** and the sealing droplet **29** on the first opening **25** of measurement device **10**. As illustrated in FIG. **10***a*, a sealing droplet **29**, that may be from silicon material or the like, may be placed on the first opening **25** after the microfluidic network comprising the microfluidic channel **60** and the sample channel **26** has been filled with a liquid prior to use of the measurement device **10**. The sealing droplet **29** thus prevents any evaporation of liquid from the microfluidic network through the first opening **25**. A further sealing **34**, for example in form of a tape or foil may be applied on top of sealing droplet **29**. When a patient or user wants to use the measurement device **10**, he removes the sealing **34** and the sealing droplet **29** away, before applying the liquid sample **5** to the first opening **25**. The sealing droplet **29** may be attached to the sealing **34** in order to facilitate its removal.

The sealing **34** may also comprise a hole **35** aligned substantially on top of the first opening **25** when the sealing **34** is placed on the measurement surface **20** of measurement device **10** as illustrated in FIG. **10***b*. In this case, the sealing droplet **29** may extend through the hole **35** in the sealing **34** for secure attachment. Thus the sealing droplet **29** is removed form the first opening **25** when a user or patient removes the sealing **34** prior to use of the measurement device **10**.

The sealing **34** may also be directly attached to the measurement surface **20** of measurement device **10**. The sealing **34** may thus directly seal the first opening **25**. The sealing may be a tape or a foil, made from or covered by silicone or other suitable material.

The sealing **34** and eventually the sealing droplet **29** may also be attached to the closure device **30**. In this case, the sealing is removed when the closure device **30** is opened prior to use of the measurement device **10**. The sealing may also be applied when closing the closure device **30** after placing the liquid sample **5** on the measurement surface **20** in order to prevent contamination and evaporation of the liquid sample **5**.

A person skilled in the art will understand that the sealing **34** described above with respect to the first opening **25** can also be applied to further openings in the measurement device **10**, for example to the second opening **27** illustrated describe with respect to in FIG. **5**.

FIG. **11** shows the handling unit **200** of the present invention with a locking device **214** for fixing the measurement device **10** in the handling unit **200**. The measurement device **10** may be inserted through first opening **210** into handling unit **200**, as illustrated in FIG. **2***a*. A locking device **214** in form of a rim may be provided at the opening **210**. Thus, the width of the opening **210** in at least one direction may be somewhat smaller or equal to the corresponding size of the measurement device **10**. The locking device **214** may serve as a fixation or snap-in mechanism for the measurement device **10** in the handling unit **200**.

FIGS. **12***a* and **12***b* shows the insertion of measurement device **10** into the handling unit **200** through a third opening **230** provided in the handling unit **200**. The third opening may be provided on an opposite side to first side **202** of handling unit **200**. Thus, the first opening **210** in handling unit **200** can be smaller in size and provide essentially only access to the first opening **25** on the measurement surface **20**. In this way, the contact seal for preventing sample liquid form coming into contact with the plug portion **40** can be substantially large in size. Furthermore, positioning of the measurement surface **20** and the first opening **25** can be carried out more precisely.

The third opening **230** may also be combined with the second opening **220** to form one enlarged opening for the plug portion **40** and the insertion of the measurement device **10**.

A locking device **234** that may be snap-in mechanism is provided at handling unit **200** and/or measurement device **10** in order to ensure fixation and correct positioning of the measurement device **10** inside the handling unit **200**, as illustrated in FIG. **12***b*. The seal **34**, the permeable layer **32** or other means provided in the handling unit **200** may provide a counterforce for when the measurement device **10** is inserted to ensure the closure of the first opening **25** in order to prevent contamination and evaporation

FIG. **13** shows a locking mechanism for closing the handling unit **200** with the closure device **30**. The closure device **30** may be provided with a hook **38**, that may engage with a corresponding notch **238** at the handling unit **200**, when the closure device **30** is positioned on the first surface **202** of handling unit **200** in order to cover and protect the measurement surface **20** and opening **25**, in particular after a liquid sample has been placed on the opening **25** of the measurement device **10**. The hook **38** and the notch **238** may engage with each other in non-removable manner forming a snap-in locking device. In this case, after closing the closure device **30**, the handling unit **200** can not be reopened and thus not be reused. This prevents contamination of the sample as well as falsification of the measurement results.

It is obvious that other snap-in or locking mechanisms can be used with the invention. For example, the locking mechanism may be provided as a mechanism that can be opened and closed several times for allowing multiple access to the measurement surface. Such mechanisms are commonly known and widely used.

The invention has been described with respect to several embodiments. It will, however, be clear to those skilled in the art that the invention is not limited thereto. Rather the scope of the invention is to be interpreted in conjunction with the following claims.

The invention claimed is:

1. A measurement sample handling device comprising a handling unit and a measurement device for taking a liquid sample, the measurement device comprising:

at least one channel, the at least one channel being filled with a solution prior to use;

a measurement portion with a measurement surface for being in use contacted with the liquid sample, wherein the measurement portion comprises at least one first channel opening providing access to the at least one channel in the measurement device;

a plug portion having a plurality of electrical contacts, wherein the plug portion is mountable to a socket of a measurement evaluation apparatus,

the handling unit having:

at least a first opening,

at least a second opening, and

a removable seal for preventing leakage of the solution from the at least one channel, wherein the seal is removable by a user prior to the use of the measurement device

wherein the first opening provides access to the measurement surface for placement of the liquid sample after insertion of the measurement device, the second opening provides access to the electrical contacts after insertion of the measurement device, and the first opening and the second opening are so arranged that, after insertion of the measurement device, the handling unit provides an electrical contact seal for sealing the measurement surface from at least one of the plurality of electrical contacts; and

wherein the measurement sample handling device comprises means for preventing evaporation comprising a second channel opening fluidly connected to the at least one first channel opening.

2. The measurement sample handling device of claim **1**, wherein the plug portion is located on a different side of the measurement device with respect to the measurement surface.

3. The measurement sample handling device of claim **1**, wherein the measurement device is at least partially made from glass material.

4. The measurement sample handling device of claim **1**, further comprising electrodes arranged along the at least one channel.

5. The measurement sample handling device of claim **4**, wherein the electrodes comprise conductivity electrodes.

6. The measurement sample handling device of claim **4**, wherein the electrodes comprise electrophoresis electrodes.

7. The measurement sample handling device of claim **4**, wherein the electrodes comprise at least one opening electrode for measuring the presence of sample liquid at the at least one first channel opening.

8. The measurement sample handling device of claim **7**, wherein the at least one opening electrode is adapted for measuring at least one parameter of the sample liquid.

9. The measurement sample handling device of claim **4**, wherein the electrodes comprise at least one control electrode for measuring at least one parameter in a supply channel.

10. The measurement sample handling device of claim wherein the second channel opening is substantially larger in size than the at least one first channel opening.

11. The measurement sample handling device of claim **1**, wherein the measurement portion and the plug portion are realized in one piece.

12. The measurement sample handling device of claim **1**, wherein the liquid sample is a sample of a body fluid.

13. The measurement sample handling device of claim **1**, wherein the measurement device is adapted to measure lithium in the liquid sample.

14. The measurement sample handling device of claim **1**, further comprising a temperature sensor.

15. The measurement sample handling device of claim **1**, further comprising non-active electrical elements.

16. The measurement sample handling device of claim **1**, wherein the handling unit is substantially larger in size than the measurement device.

17. The measurement sample handling device of claim **1**, wherein the measurement portion of the measurement device is located inside the handling unit.

18. The measurement sample handling device of claim **1**, further comprising a third opening for inserting of the measurement device into the handling unit.

19. The measurement sample handling device of claim **1**, further comprising a measurement device locking mechanism for locking the measurement device in the handling unit.

20. The measurement sample handling device of claim **1**, wherein the measurement surface is substantially concealable by a closure device.

21. The measurement sample handling device of claim **20**, further comprising the removable seal between the closure device and the measurement surface for substantially sealing the measurement surface from surroundings.

22. The measurement sample handling device of claim **20**, wherein the closure device is substantially larger in size than the measurement surface.

23. The measurement sample handling device of claim **1**, wherein the handling unit and the closure device are realized in one piece.

24. The measurement sample handling device of claim **1**, further comprising a closure device locking mechanism for concealing the measurement surface with the closured device.

25. The measurement sample handling device of claim **1**, wherein at least one geometrical parameter of the handling unit is adapted to fit into the socket.

26. A measurement sample handling device comprising a handling unit and a measurement device for taking a liquid sample, the measurement device comprising:

at least one channel, the at least one channel being filled with a solution prior to use;

a measurement portion with a measurement surface for being in use contacted with the liquid sample, wherein the measurement portion comprises:

a first channel opening providing access to the at least one channel in the measurement device;

a second channel opening for modifying evaporation behavior at the first channel opening, wherein the second channel opening is fluidly connected to the at least one first channel opening, wherein the second channel opening is substantially larger in size than the first channel opening so that the level of liquid in the first channel opening remains at a generally constant level when liquid evaporates from the first and second openings;

a plug portion having a plurality of electrical contacts, wherein the plug portion is mountable to a socket of a measurement evaluation apparatus, the handling unit having:

at least a first opening,

at least a second opening, and

a removable seal for preventing leakage of the solution from the at least one channel, wherein the seal is removable by a user prior to the use of the measurement device

wherein the first opening provides access to the measurement surface for placement of the liquid sample after insertion of the measurement device, the second opening provides access to the electrical contacts after insertion of the measurement device, and the first opening and the second opening are so arranged that, after insertion of the measurement device, the handling unit provides an electrical contact seal for sealing the measurement surface from at least one of the plurality of electrical contacts.

27. The measurement sample handling device of claim **26**, wherein the difference in size between the first channel opening and the second channel opening results in a difference of pressure in the first opening and in the second opening thereby modifying the evaporation behavior at the first channel opening.

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